RÉSUMÉ AND CRITIQUE OF THE TABULATED COLLEGE REQUIREMENTS IN NATURAL SCIENCES

In reviewing the tabulated requirements of fifty-six of the most important institutions, we note that eighteen have no requirement in natural science for any course. These are Princeton, Cornell, Columbia, Barnard, Vanderbilt, Hamilton, University of Pennsylvania, Washington and Lee, University of North Carolina, Williams, Union, Brown, Tulane, Vassar, Washington and Jefferson, University of Texas, Evelyn and Colby. To these should be added Yale and some others which require no natural science for any courses in the college of liberal arts or the equivalent, although they may for courses in engineering and technical schools.

There are thirty institutions requiring physics, either alone or with other requirements, or in a list of elective requirements. They are Amherst, University of California, Beloit, Columbian University, Bowdoin, Cornell College, University of Wisconsin, Wesleyan, University of Kansas, University of Colorado, University of Rochester, Bryn Mawr, Colgate, University of Tennessee, University of Illinois, Tufts, Lafayette, Indiana University, University of Iowa, University of Missouri, University of Minnesota, Harvard, University of Chicago, Haverford, Lehigh, Northwestern University, Wellesley, University of Nebraska, Western Reserve, Leland Stanford, and University of Michigan.

There are three institutions where physics is the sole requirement in natural science, viz.: Columbia University, Lafayette, and Lehigh; this is also true of the requirements for the B.A. course of many colleges, as University of Colorado.

There are ten institutions requiring physics with some other study: De Pauw, University of California, Beloit, Wesleyan, University of Kansas, University of Tennessee, University of Minnesota, University of Michigan (B A.), University of Illi-

nois, and Smith; also several others place physics in the list of elective studies.

There are three institutions requiring only physics *or* chemistry, viz.: Amherst, Bowdoin, and Bryn Mawr; also several others place physics and chemistry in a list where one or more is required.

There are four institutions requiring physics *and* chemistry, viz.: Harvard, Rutgers (B.S.), Colgate, Western Reserve; also others place both physics and chemistry in a list where two at least are required.

There are thirteen institutions requiring physics and chemistry, and some other good natural science work, as biology or botany, viz.: University of California, Beloit, Wesleyan, University of Colorado, University of Illinois, Tufts, University of Minnesota (B.S.), University of Chicago, Northwestern University (B.S.), University of Nebraska (B.S.), Leland Stanford; there are also several other institutions requiring three or more in a list which includes physics, chemistry and some biological subjects (botany, zoölogy, etc.), as the University of Michigan and Cornell College.

There are three institutions requiring physics with some biological subject, as botany, with or without some other subject, viz.: University of Wisconsin, Northwestern University (B.A.), University of Michigan (B.A.).

There are twenty-two institutions requiring some biological subjects, or accepting them as optionals, with or without other subjects, viz.: University of California, Beloit, Cornell College, University of Wisconsin, Wesleyan, University of Colorado, Johns Hopkins, Bryn Mawr, University of Illinois, Tufts, Indiana University, University of Iowa, University of Missouri, University of Minnesota, University of Chicago, Northwestern University, Wellesley, University of Nebraska, Leland Stanford, University of Michigan, Smith, University of Rochester.

There are twenty-four institutions requiring chemistry or recognizing it as an elective, viz.: Amherst, University of California, Beloit, Bowdoin, University of Wisconsin, Wesleyan,

University of Colorado, University of Rochester, Johns Hopkins, Bryn Mawr, Colgate, University of Illinois, Tufts, Rutgers, University of Iowa, University of Missouri, University of Minnesota, Harvard, University of Chicago, Northwestern University, Wellesley, University of Nebraska, Leland Stanford, University of Michigan.

There are fourteen institutions requiring or recognizing as elective some one or more of the physiographic studies, *e. g.*, physical geography, astronomy, geology, etc., viz.: Beloit, Cornell, University of Colorado, University of Rochester, Johns Hopkins, Bryn Mawr, University of Illinois, Tufts, University of Iowa, Harvard, University of Chicago, Northwestern University, Wellesley, University of Michigan.

There are fourteen institutions requiring a *time* limit or notebook equivalent, viz.: University of California, Bowdoin, University of Wisconsin, Wesleyan, University of Colorado, University of Illinois, Indiana University, University of Missouri, University of Minnesota, Harvard, University of Chicago, Northwestern University, Wellesley, Leland Stanford. Doubtless others are to be added to this list, but it is to be noted that the *vagueness* of statement commonly found is a serious self-criticism and indicates one of many opportunities for improvement in the catalogue statement of the particular requirement. The catalogues of Harvard, University of Chicago, Leland Stanford, and the like are refreshing in the clear detailed statement of what is wanted.

In summation we notice that while the average requirement is very low, incoherent, and illogical, yet there are thirty-four institutions recognizing physics, twenty-four recognizing chemistry, and twenty-two recognizing biology or biological subjects as botany, zoölogy, etc.

Further, there are sixteen institutions which recognize the physiographic subjects of physical geography, astronomy, geology, and "physiography."

ABSTRACT OF TABULATED REQUIREMENTS.

Total number of institutions enumerated	56
With no requirement for any course	18
Physics either required or elective	32
Physics alone required	13
Requiring physics and some other study	10
Requiring physics or chemistry	3
Requiring physics and chemistry	4
Requiring physics and chemistry and biology	13
Requiring physics and biological subjects	3
Requiring chemistry, or as an optional	24
Requiring biological subjects, or as an optional	22
Requiring physiographic subjects, or as an optional	16
Emphasizing a time limit or the equivalent	14
Accepting laboratory notebooks in examination	10

The institutions whose catalogues speak with emphatic sincerity in the desire to build up a thorough, logical B.S. preparatory course, a course of both discipline and culture, seem at present to be : the State Universities of Michigan, Wisconsin, Minnesota, Illinois, Colorado, California, Nebraska, Indiana, and the private institutions, University of Chicago, Northwestern University, Leland Stanford, Tufts, Beloit, and Wesleyan. Not all of them are equally logical, methodical, and exacting, but the general purpose is evident, and is at a wide remove from those which seem to dally with the problem, or which say *de facto*, that they prefer that their students should come to them with no physics, or chemistry, or biology, rather than with a preparation which may be poor, until the fitting school can do better.

But here it should be candidly acknowledged, or rather emphasized, that such older institutions, as Harvard, may be more mercilessly exacting on a seemingly lower requirement, than others may be on a seemingly higher standard, and hence the practical standard may be quite a different matter ; and it is a point not to be forgotten that while many of the more progressive institutions may find it seemingly good provisional policy to be good-naturedly easy on admission standards for a

brief time, yet a too easy admission is not to be tolerated long by any genuinely honest or self-respecting institution.

The B.S. course cannot be patterned after the classical, and yet it must compete with its rival; and this means that no school has time or money, no teacher has time or strength or intelligence to use in any way except that involving the best possible discipline of the hands and head of the student. This leads us easily to the position that the main time must be given to those subjects which are fundamental and which can be adapted to bring out this discipline. Hence physiography not being a fundamental disciplinary study (although its value as an informing study is very great), should be limited to the first year of a four year's preparatory course. None of the physiographic subjects can be thoroughly mastered till after thorough courses in physics (the study of matter and energy *per se*), chemistry (the study of the kinds of matter), and biology (the study of living matter).

To give an illustration, what real progress can be made in modern geology without a preliminary study of physics for dynamic geology, of chemistry and mineralogy for chemical and petrographical geology, and of the biological study of animal and plant forms for palæontology? Or again, in modern astronomy, how progress without physics and chemistry? Hence physiography has a slight claim to a place as a popular introduction to the general field, in the first year of the course. Let us hope that the promising innovation of "science in the grades" will remove even this in a few years.

The work in physics already done by the majority of fitting schools, shows clearly that its place for one full year's work as a minimum, comes next in the course.

The work in chemistry logically follows next; and although the requirements are woefully low, yet the demand is for a minimum of one year; it is probable that the "Remsen" system of teaching a *few* typical elements well, followed by a clear exposition of the facts implying the atomic theory, is the best. This should probably be followed by a systematic study of the "gram-

mar of chemistry," *i. e.*, the examination of the leading elements with the systematic mastery of their compounds "from reduced to oxidized extreme." This involves much of the material commonly called qualitative analysis, but in our judgment, although the simpler separation comes inseparably with the year's work in chemistry, yet at present thorough analysis should be left for college. There is plenty of encyclopedic material, indispensable for a good foundation in chemistry, which should be attacked during the first year. This means good reference books studied topically.

It goes without saying that lecture, quiz—laboratory-work quiz—reading, quiz—is the order and substance of the method for a large and thorough acquisition of knowledge and discipline in each of the triad, physics, chemistry, and biology; and the logical order is probably as indicated, with a full year of each. It may be noted that some schools find it practical to teach physics and chemistry during two years together, on the so-called "sandwich plan," so closely are they related (this has been successfully done in the Omaha High School).[1]

A feature in these tables which deserves notice is the usually low grade of work required in biological science for admittance to college. With the exception of a very small number of progressive colleges the old fashioned systematic botany, with its herbarium of fifty or a hundred plants, collected or bought by the student, still reigns supreme. Where zoölogy is required at all it is usually evident that it is mere book work, and that not even the equivalent of so much laboratory work as is represented by the herbarium is demanded.

The state of things indicated by these college requirements is certainly a curious one; the group of sciences which most nearly touch man as a living being, are in a very much inferior position to physics and chemistry in the preparatory curriculum. One cannot conceive of physics being taught today without the laws of motion, or chemistry without the atomic theory, yet most colleges are satisfied with a kind of botany and zoölogy,

[1] The paragraphs on the teaching of Biology are by Professor John Gardiner.

which can only be compared to such physics and such chemistry. A student who is required to know all about the atomic theory, gives perfect satisfaction in botany if he can "analyze" (save the mark!) a grass or a composite, though he may hardly have heard of protoplasm, may believe that the essential part of a cell is its wall, and may think that the root of a plant is simply an animated sponge.

Yet there can be no doubt as to the opinion of the authorities in such matters—the biologists themselves in America and Europe. One or two aberrant specimens among them think that biology ought not to be attacked before the college period. One or two others think that botany alone or zoölogy alone ought to be done in the preparatory school, but the great majority believe in the idea of a year's work in General Biology, the kind of work exemplified by the books of Huxley and Martin, Dodge, Boyer, etc. They hold, I believe, that, neither as a discipline nor as a culture study, have the old fashioned botany and zoölogy the smallest value; while on the other hand, General Biology properly taught, is at once a valuable discipline and a true source of culture. There is all the difference in the world, from both points of view, between analyzing a frog by the help of Jordan, and dissecting it. The knowledge of the mechanism of the frog's heart is worth ten thousand times as much as the knowledge of the precise differences between *Rena virescens* and *Rena areolata*. And just so the knowledge of the way in which green plants feed and breathe, of the homologies between fern and flowering plant, is worth many times as much as the ability to discriminate between *Astragalus* and *Oxytropis*.

In order that such biology as this may be taught satisfactorily it must have a definite place in the programme of studies; it must follow physics and chemistry; for otherwise much of it is incomprehensible. And here perhaps is one reason for its unpopularity; for the teacher of each science is anxious to have as mature pupils as possible. The old fashioned biology could be put anywhere; the new can not. It is also said that it costs too much to teach the new kind of biology, and that it is impos-

sible to get the right kind of teachers. The University of Chicago has apparently sanctioned the first of these objections, though one knows of high schools even in small and poor communities where the cost of compound miscroscopes has proved a difficulty that could be overcome. And such institutions as the University of Michigan can give evidence that qualified biologists are being turned out in greater numbers than the present demand requires.

Sooner or later the change must come, and it is to be hoped that when the dust of the present discussion on college requirements shall have cleared away, it will be found that a true biology will have taken the place of the sham which has so long represented the popular ideal of such work in preparatory courses.

The practical question now comes up, viz., what can the college induce the high and preparatory school to do? Let us note here—both from *a priori* principle, and from practical experience—that the latter will probably do just in proportion as they have responsibility intrusted to them. The schools can do good disciplinary work in physics, chemistry, and biology, and in time they will do it well.

On the other hand, what can the high and preparatory schools induce the colleges to accept? The fact that nine institutions, and those largely the best, already accept the laboratory notebook as evidence in entrance examinations, proves that already the schools have obtained a large concession from the colleges. Some of the institutions which recognize the laboratory notebook in evidence are Harvard, Bowdoin, Wesleyan, Johns Hopkins, University of Illinois, University of Minnesota, University of Chicago, Northwestern University, Leland Stanford, Dartmouth.

Another important concession is the acceptance of some of the "advanced" requirements *as credit in the college course*, a dangerous concession possibly, but certainly a very generous one to the preparatory school.

The adaptation of the extreme B.A. to the extreme B.S.

course will be, as present tendencies indicate, a natural compromise. Thus, although physics is not akin to the material of the classical course, yet it is the first subject to be introduced. In making up the compromise Ph.B course, the standard of exchange should be made on the strict barter principle of equal work and discipline for equal work and discipline; not the substitution for two or three years in Greek, one (!) year of natural science, as is too frequently done.

Regarding the practical adjustment of the time schedule, that can be settled only after it is determined what the desired requirements shall be. A very serious problem is that which the large city schools are called upon to face, in the establishment of laboratory courses in physics, chemistry or biology, for classes whose numbers run into the hundreds. We believe that patience and courage voice the keynote of the solution. We shall not get more than we ask for, but the people will, in the long run, willingly pay for a good thing.

Finally we must consider the demands of the "finishing course" idea, in asking for an expensive waste of time on the physiographic studies. Some help, as already suggested, will surely come in time from the introduction of "science in the grades." Most teachers will probably agree with the maxim of President Eliot, that "the best preparatory course is the best finishing course." Meanwhile the practical problem remains, viz., to combine the two to the satisfaction of the tax-payer and the educator. We do not doubt that it will be done by the intelligence, energy and experience of the American teacher.

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